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Carbon Sequestration in Tropical Tree Crop Systems – especially in Rubber Plantations (Hevea brasiliensis)

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Carbon Sequestration in Tropical Tree Crop Systems – especially in Rubber Plantations (*Hevea brasiliensis*)

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Outline

- Introduction
- Case Study from Ghana
- Research conducted
- REDD+ and rubber plantations
- Examples of rubber plantation projects
- Summary

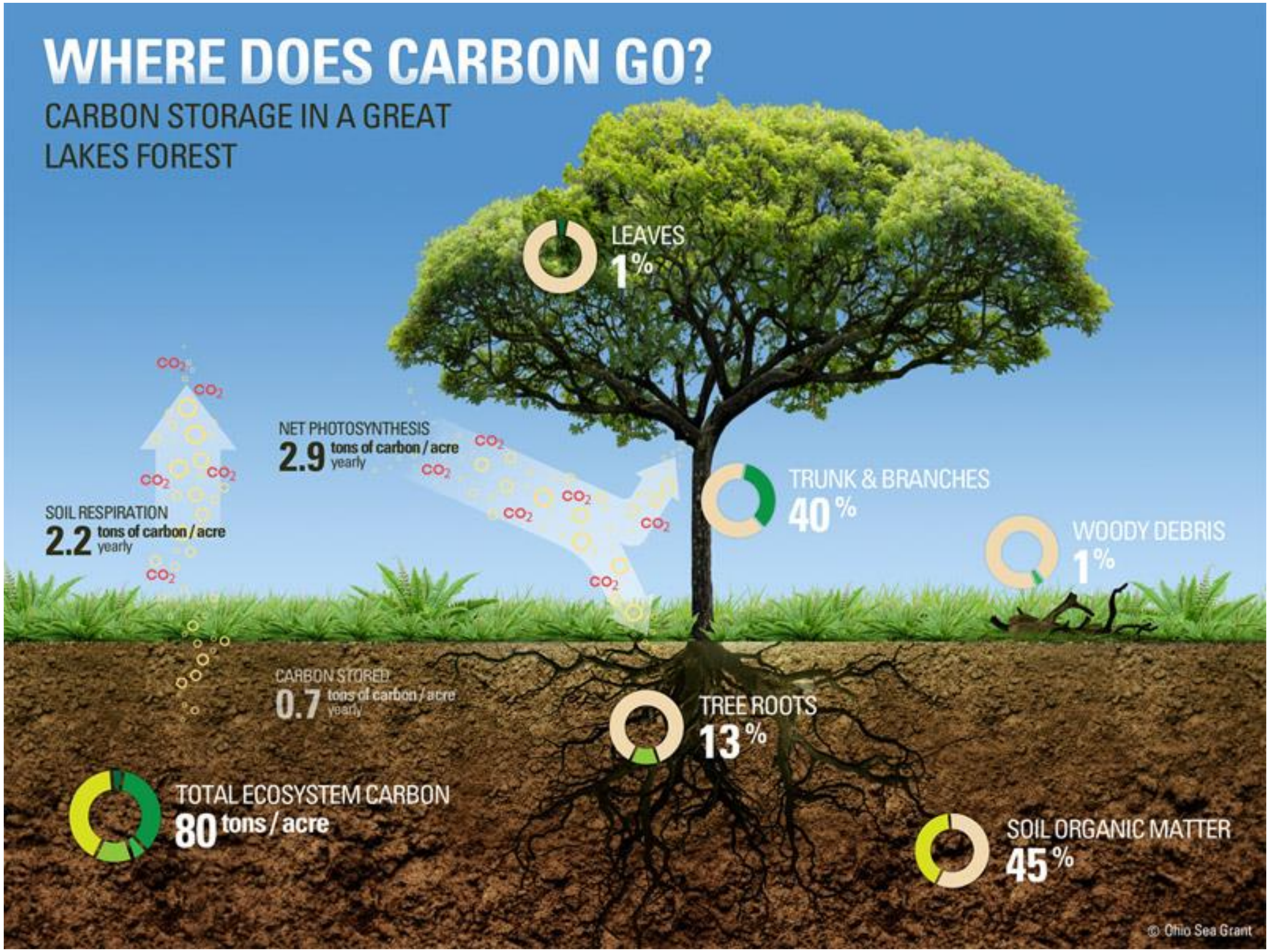
Langkawi, Malaysia - Photo: R. Kongsager 2009

Introduction

- Land-use and land-cover change has contributed about 33% of global carbon emissions over the past 150 years
- However the current relative contribution has declined to 10-13% annually (Houghton et al. 2012)
- A growing interest in lowering the emissions of greenhouse gases from different types of land-use
- Compared to other tropical agricultural crops
- Potential to increase sustainable development if projects are implemented in the right way
- REDD+ (payment scheme)

- Question: Are rubber plantations a good climate change mitigation option?

Carbon Pools in Tree Systems



Case Study

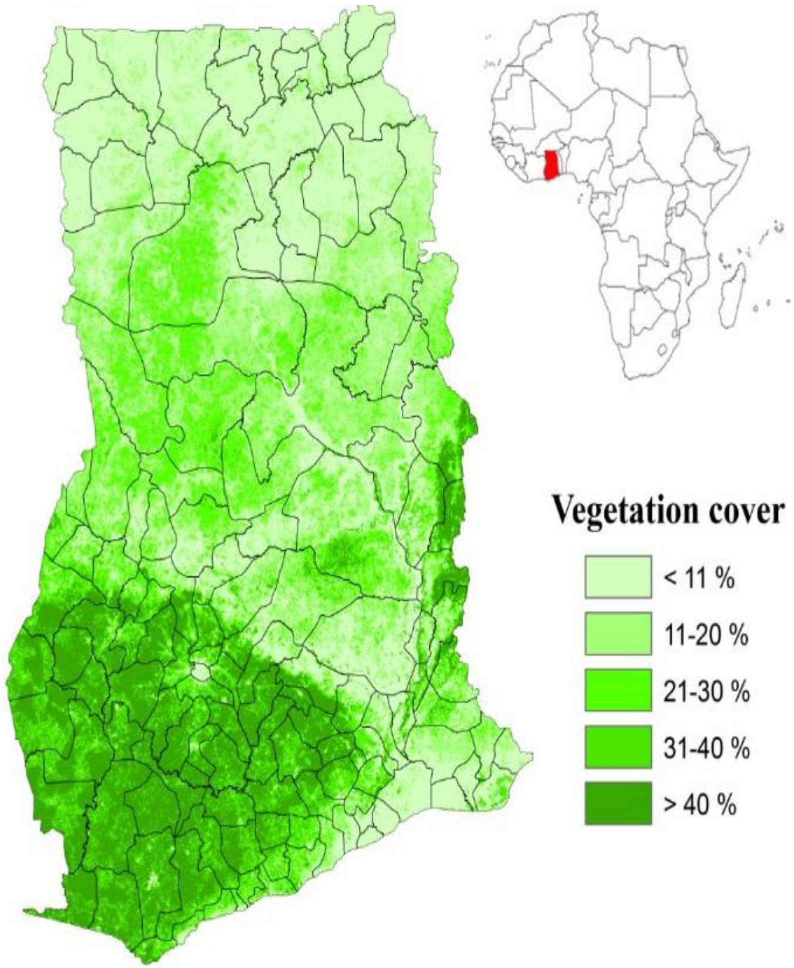


Figure 2: MODIS Vegetation Continuous Field of Ghana 2005 (processed by authors).

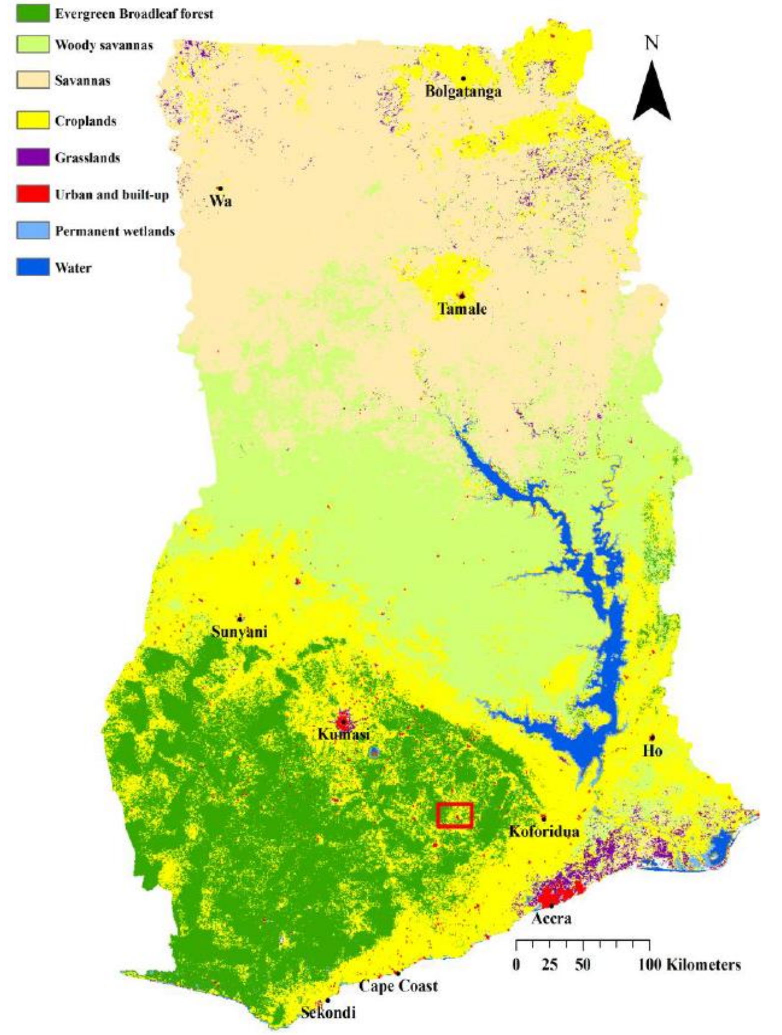


Figure 4: MODIS MCD12Q1 yearly land cover type 2008 (500m) from NASA (processed by authors). The red square indicates the area of interest that is enlarged in Figure 5.

Source: Kongsager et al. 2012

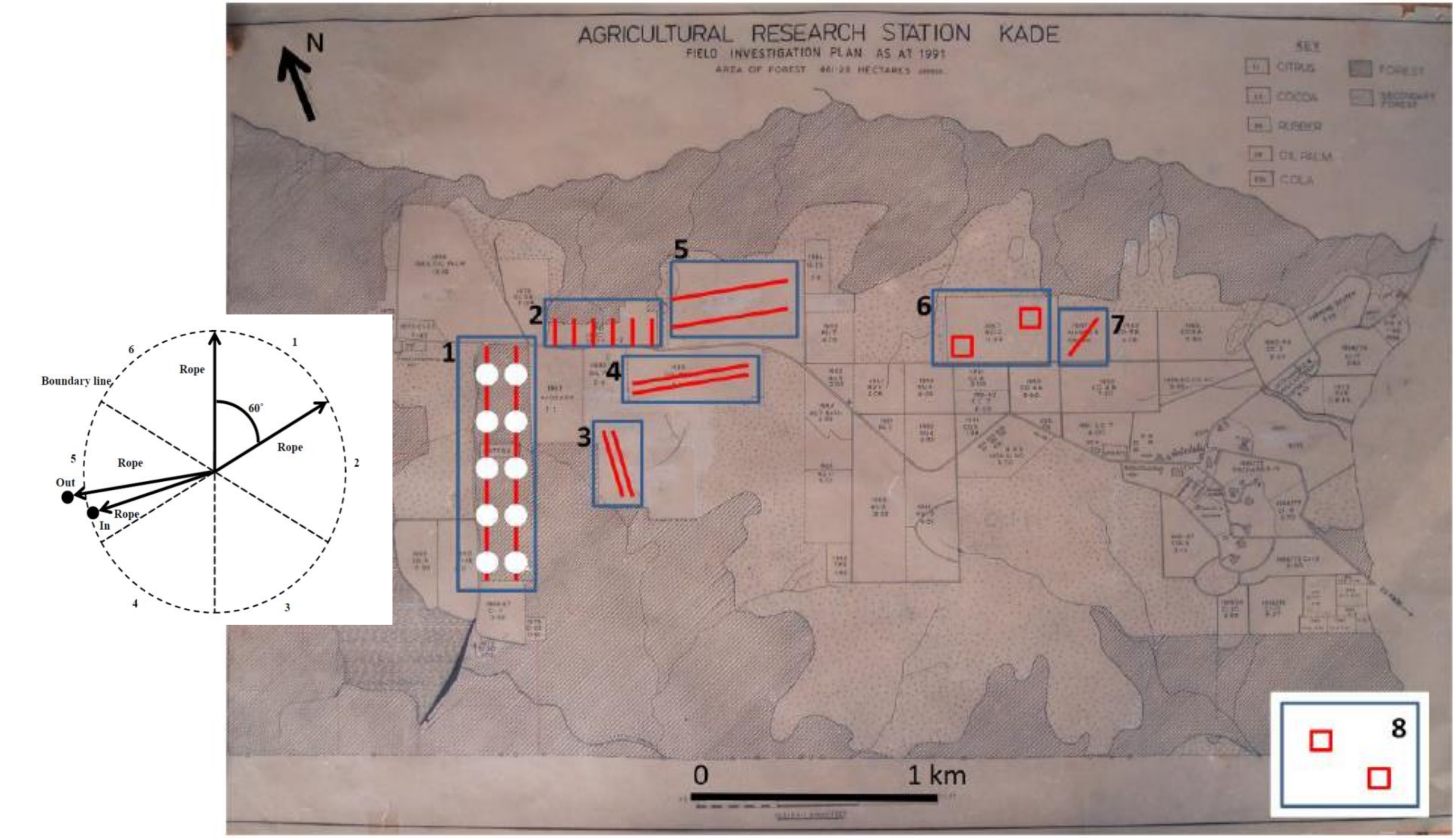


Figure 6: Map of ARC-Kade. 1: Primary forest (> 100 years). 2: Orange plantation (15 years). 3: Oil palm plantation (16 years). 4: Oil palm plantation (23 years). 5: Oil palm plantation (7 years) 6: Rubber plantation (44 years). 7: Cacao plantation (21 years). 8: Rubber plantation (12 years) 25 km south of Kade. Red lines indicate transects, white circles indicate primary forest plots, and red squares in 6 and 8 indicate rubber plots.

Climate

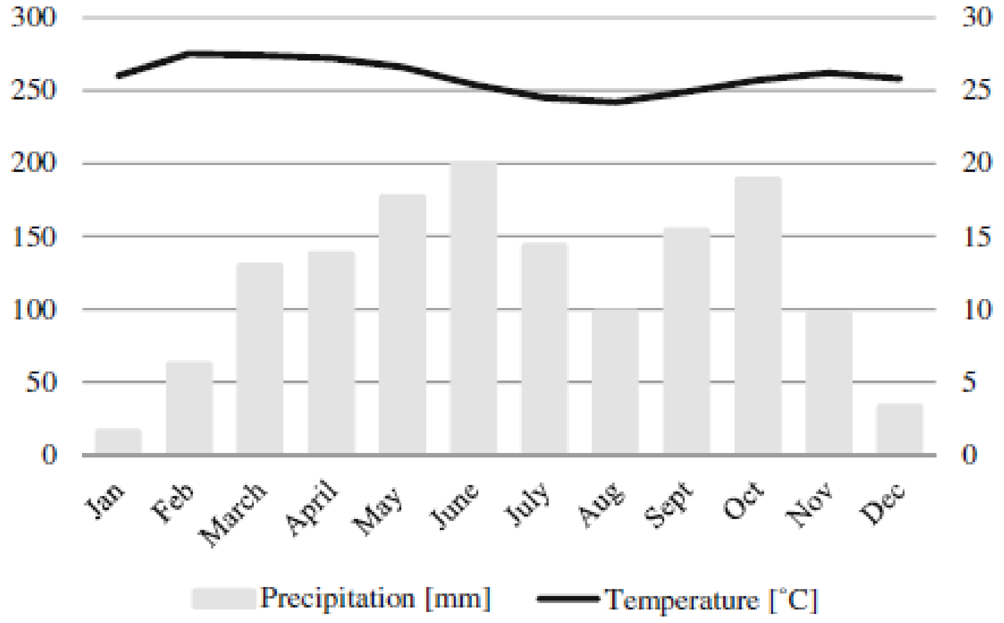


Fig. 2 Climate diagram, ARC-Kade, 1980-2010. Annual averages: precipitation 1,425 mm; temperature 26 °C. Data for 1984, 2005, 2006 and 2007 are incomplete and not included (data provided by Dr S. Adjei-Nsiah 2011)

Note: compared to Malaysia: temp the same, but precipitation is around 1000mm higher in Malaysia

Plantations Measured

Table 1 Specifications of the plantation measurements

	Cocoa	Oil palm	Rubber	Orange
Variable measured	Diameter at breast height	Height	Diameter at breast height	Basal area
Total number of trees/stems measured	246	360 (120 from each year)	442 (178 from 1967 and 264 from 1999)	108 (94 alive and 14 dead/missing)
Number of plantations measured	1	3	2	1
Age	21 years old (planted in 1990). Shade trees 40 years old.	7 years old (planted in 2004), 16 years old (planted in 1995) and 23 years old (planted in 1988)	12 years old (planted in 1999) and 44 years old (planted in 1967).	25 years old (planted in 1986)
Total size of area	13.9 ha	50.04 ha (2004), 13.9 ha (1995), and 30.58 ha (1988)	55.6 ha (1999) and 38.92 ha (1967)	20.71 ha
Planting density	1,097.39 stands/ha	144 stands/ha	Unknown	266.93 stands/ha
Species	Theobroma cacao	Elaeis guineensis (Tenera)	Hevea brasiliensis	Citrus sinesis (Late valencia)
Type of plot	Since distinct rows of cocoa trees were absent, circular plots with a radius of 20 m were chosen.	Since no palms were missing in the rows, the oil palm plantations were measured in rows equivalent to two acres (0.4047 ha) as transects through each plantation.	Because of incomplete rows, we measured in 60×60 m squared plots instead of only equivalent rows. Trees were missing since no replanting took place if a tree died, as the older trees would shade the younger trees too much.	The plantation was measured in equivalent rows.
Plots	5 plots of 314.15 m^2=0.16 ha=4 % of the total population.	1 transect of 120 trees in each plantation=0.81 ha=6 % (2004), 20 % (1995) and 9 % (1988) of the total population.	2 plots of 3,600 m^2 (in both plantations)= 0.72 ha=4,5 % (1999) and 16 % (1967) of the total population.	6 rows of 18 trees=108 trees=0.405 ha=6.7 % of the total population.

Results

Table 2 Carbon content in plantations

Type	Age [years]	Aboveground [tC/ha]	Accumulation [tC/ha/year]	Time-averaged carbon content (30 year rotation)
Cocoa	21	65.0	3.1	46
Oil Palm	7	21.7	3.1	
Oil palm	16	28.0	1.8	30
Oil Palm	23	45.3	2.0	
Rubber	12	61.5	5.1	75
Rubber	44	213.6	4.9	
Orange	25	76.3	3.1	46

In comparison was the carbon content in the unmanaged natural forest (> 100 years) at the research station measured to be 130.2 tC/ha (permanent content – no rotation)

Rubber plantation 44 years, ARC-Kade, Ghana - Photo: J. Napier 2011

Other Case Studies

Average carbon content in aboveground biomass	Comment	Location	Source
75 ton C/ha	with a 30 year rotation period	Ghana	Kongsager et al. 2012
90 ton C/ha	permanent agroforest	Indonesia	Palm et al. 2005
50 ton C/ha	intensively managed	Indonesia	Palm et al. 2005
93 ton C/ha	38-year chronosequence	China	Yang et al. 2005
76 ton C/ha	14-year-old stands	Ghana	Wauters et al. 2008
42 ton C/ha	14-year-old stands	Brazil	Wauters et al. 2008

Average carbon content of natural forests for all tropics: 94 tC/ha (Houghton 2005)

Carbon in Oil Palm

Average carbon content in aboveground biomass	Comment	Location	Source
30 ton C/ha	with a 30 year rotation period	Ghana	Kongsager et al. 2012
48 ton C/ha	rotation times of 25 years	Indonesia	Palm et al. 2005
91 ton C/ha	20 year rotation time	Indonesia	Murdiyarso 2002
36 ton C/ha		Malaysia	Henson 2003
30 ton C/ha	51 oil palm plantations taken from several studies	Global	Germer and Sauerborn 2008

Agroforestry in General

- Carbon sequestration potential greater than crop or pasture systems

  Albrecht and Kandji 2003; Dixon 1995; Lal 2004; Montagnini and Nair 2004; Mutuo et al. 2005; Nair et al. 2009; Niles et al. 2002; Oelbermann et al. 2004; Palm et al. 2004; Pandey 2007; Roshetko et al. 2007; Sanchez 2000; Schroeder 1994; Watson et al. 2000

- Lower GHG emissions compared to cropping systems

  Mutuo et al. 2005; Palm et al. 2004; Schroeder 1994; Watson et al. 2000

- Agroforestry systems can regain 35% of the carbon stock and store soil carbon at a rate of 80–100% that of forest, compared to 12% and 50 % respectively on crop or pastureland

  Palm et al. 2004; Watson et al. 2000

- However, systems vary considerably and sequestration potential depends on practices used

  Albrecht and Kandji 2003; Current et al. 1995; Mutuo et al. 2005

Main source: Anderson and Zerriffi 2012

REDD+

- REDD+ is a payment scheme
- Negociations are in progress, but the guidelines will most likely not be stricter than the ones in the Kyoto P. (CDM)
  - Crown cover: 10-30%
  - Area: 0.5-1.0 ha
  - Height: 2-5 m
- Scenarios
  - From agriculture to rubber plantation = reforestation/afforestation
  - From forest to rubber plantation = forest degradation
- Rubber vs Oil Palm

Source: Personal communication: **Peter Aarup Iversen,** UN-REDD Technical Specialist, UNDP Cambodia

Examples of rubber projects

- Promoting Sustainable Development through Natural Rubber Tree Plantations in Guatemala
- VCS (Voluntary Canbon Standard) – applying the A/R CDM methodology
- 3,900,439 tCO^2 over 42 years through the reforestation of 2,366.16 ha with rubber trees.
- Establish in degraded and degrading lands
- Traditional use: cattle grazing
- Smallholders on privat land
- Timber will be certified under the Forest Stewardship Council (FSC)
- Carbon credit revenue is spend on project activities

Examples of a… (cont)

- Baseline study to show eligibility (not forested on December 31st 1989 + no forest in the last 22 years)
- Additionality: compared to Business As Usual and four other alternative land use scenarios
- Measurements: Aboveground (Diameter at breast height) + Belowground (ratio of aboveground)
- Leakage: Grazing animals were transferred to identified grasslands or slaughtered

Examples of a… (cont)

- The productive life is approximately 40 years
- Productivity declines after ca 20 years
- Rubber will be extracted starting in year six continuing for a minimum of 30 years
- Harvested for timber (FSC)
- Plantation will be replanted
- Environmental Impacts
- Social impacts

Source: http://www.rainforest-alliance.org/climate/projects/pica-project

Examples of a… (cont)

Colombia (78,160 tCO^2)

- Establishing 4,109 ha of rubber plantations on cattle pastures

Lao People's Democratic Republic (40,672 tCO^2)

- Establishing 1,046 ha of rubber plantations on degraded and abandoned grasslands
- Main aims are:
  - poverty alleviation and wealth creation in rural areas
  - communities empowerment through active participation in all stages of the project
  - improvement of basic infrastructure for rural communities
- Technical and investment barrier for small-farmers

Source: http://cdm.unfccc.int/Projects/Validation

Summary

Are rubber plantations a good idea in regard to climate change mitigation?

- Suitable location in regard to sequestration
- Level of intensity
- Established on land with modest carbon content, such as degraded forest or agricultural land

A good idea in regard to Sustainable Development?

- Impact on Local livelihood and Biodiversity

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Thank you for your attention…

Kade, Ghana - Photo: J. Napier 2011

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